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TECHNICAL AND ECONOMIC ASPECTS OR THE INDUSTRIALIZATION OF BUILDING

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Economic Commission for Europe

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TECHNICAL AND ECONOMIC ASPECTS OF THE INDUSTRIALIZATION OF BUILDING

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Introduction

1. Building materials are only one of the input factors entering into building activity in general, but certainly the most important single item of building costs. Building techniques, i.e. the different ways in which building materials and components are produced, selected, brought together and assembled in the erection of a given building, represent only one stage in the overall building process, which involves all the members of the building team from the client or the investor at one extreme to the user at the other. To reduce costs without impairing the quality of the building is the ultimate objective of technical and economic policies. These reductions can be achieved in many ways and at different stages of the building process; however, changes in building techniques are without doubt among the most effective means of bringing about an overall economy of building costs.

2. The complex problem of technical and economic policies in the field of building in general, and more particularly of house-building, have loomed large among the subjects to which the Housing Committee of the Economic Commission for Europe has devoted its attention over the last fifteen years. The present note will recall briefly some of the more recent studies carried out in this field under the aegis of the Committee and is based, strictly speaking, on European experience only. It is felt, however, that some of the problems to be faced and the approach followed in their solution may be of interest to developing countries; this particular question will be dealt with briefly in the last section of this paper.

The economic significance of residential and non-residential construction

3. Gross domestic fixed capital formation amounts to between 15 and 30 per cent of gross national product in a majority of European countries; approximately half of this goes into construction (residential building, non-residential building, civil engineering and other construction works). Housing alone represents anything between 25 and 50 per cent of gross capital formation in construction; in the majority of European countries, housing contributes by 35 to 45 per cent to gross capital formation in construction. This means that some 3 to 5 per cent of gross national product goes into investment in residential construction.

4. The general expansion of quantitative housing needs (accounted for by the backlog of neglect over the past generations, by rapid demographic growth and by the general trend towards urbanization), the constant and irreversible raising of qualitative standards and the general increase in building costs are all factors contributing towards making economies in building costs one of the main

problems of government housing policies and, in a sense, an important aspect of general economic development (1).

The Present level of house-building costs and the main factors affecting it

5. It is obvious that any systematic effort to reduce building costs must be based on thorough knowledge of their present level and on the main factors likely to affect their future development. However, it has been found that objective knowledge of actual building costs is comparatively scarce in the majority of European countries, for reasons inherent to the very nature of building activities which involve so many different partners, are spread over long periods of time and are generally difficult to be controlled.

6. Prices, i.e. the amount paid by the investors, are more easily recognizable and can be subject to statistical analysis; however, the value which can be derived from price studies is limited since prices, by their very nature, are affected by a variety of factors related to market conditions, in market economies, and to broad policy decisions, in planned economies.

7. In order to fill this gap and as part of its work programme, the Committee has undertaken several studies intended to throw light on the main components of actual house-building costs and on the factors affecting them. The work involved the collection and analysis of actual cost records on a number of building sites, broken down according to a common method.

8. Broadly speaking, the approach adopted was to have a double breakdown of building costs, one by main elements of cost (materials, labour, labour on costs, plant and machinery, site overheads, office overheads, taxes and profits), the other by elements of building, e.g. foundations, external walls, partitions, floors, roofs, etc., regrouped under three major headings: substructure, superstructure, finishes and equipment.

9. The results of the most recent enquiry carried out in this field by the Committee, covering some sixty building sites in nine European countries and a wide range of building materials and building methods - from purely traditional construction to the most recent examples of fullscale prefabrication of room-size wall and floor panels - are briefly recalled below.

10. Cost variations within a country, and sometimes even within categories of building, are as great as those between countries. This appears to be a significant characteristic of house-building activities in most European countries.

11. Taken as a whole and making allowance for the materials content of subcontractors' prices, building materials represent 60 per cent of the total cost of construction. In many cases the share of building materials in the total cost

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(1) The total number of dwellings built in 24 European countries reporting such data has grown from 3 million in 1953 to over 5½ million in 1961, i.e. a compound annual rate of increase of over 8 per cent. (See Annual Bulletin of Housing and Building Statistics in Europe, United Nations, Geneva). Assessment of objective housing requirements indicates that the number of dwellings built in Europe is likely to continue to increase steadily in the coming years if these needs have to be met at an adequate standard.

of the building is up to now only slightly affected by the transfer of operations from the building site to the factory. It would therefore appear that major economies in building costs can be achieved through a serious effort to reduce the cost and/or the quantities of materials, either on the site or at the factory.

12. The average direct labour cost in all the contracts included in the enquiry in approximately 22.5 per cent. Out of the fifty-five contracts for which data are available, thirty-nine have labour costs falling in the range of 15 to 30 per cent of the total cost. This figure is considerably lower than those considered as typical ten, or even five, years ago (1). With all the reservations to be attached to conclusions drawn from such a small sample, this appears to be a significant result of a general trend towards the reduction of the direct labour content of the building. This trend would appear even more significant if it is recalled that in the last five years, the indix of labour costs in almost all European countries has grown more rapidly than the index of material costs.

13. The general trend indicated above is consistent with the information obtained on total man-hours both on the building site and at the factory. Whereas only five years ago the figure of 20 man-hours per m^2 of gross floor area was rather unusal - except for some pilot or experimental schemes - the range seems now to be between 12 and 18 man-hours per m^2 of gross floor area, with an absolute minimum of 8.8 man-hours. The labour content appears to have been reduced substantially and there is ample indication that this trend is general and likely to continue, within obvious limits. Among the factors accounting for the reduction of labour costs and of man-hours, both on the building site and at the factory, mention should be made of better site organization, greater specialization of work, better and more frequent use of machinery and tools, the reduction in the quantity of materials used and other related aspects of the general trend towards the industrialization of building.

14. The relatively important share of building materials in the total cost sets definite limits to savings in over-all costs. In the three countries where large-panel construction has attained considerable proportions, the cost of construction by this method is in some cases substantially lower - from 10 to 20 per cent - than the cost of traditional construction. In all countries the use of large-panel construction considerably reduced the number of man-hours on site and sometimes total man-hours.

15. There appears to be little or no relationship between the actual expenditure on plant or machinery on site and the number of man-hours, the cost of labour or the total cost of building. However, the cost of plant and equipment is proportionally lower in large-panel construction than in construction by traditional methods, owing to the speeding-up of the building process and the consequent reduction of the time spent by the machines on the site, although the actual cost of the machines is greater.

16. No consistent relationship was found between the weight of materials and components and either the cost or the number of man-hours on site. It is only reasonable to assume that the reduction of the total weight of building materials and components to be handled at the factory or on the site should be conducive to savings in the number of man-hours, in labour costs, in the cost of machinery

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(1) See: "Government policies and the cost of building", E/ECE/364, 1959, part I, table II, p. 44.

needed for processing handling and transporting such components, as well as in the cost of storage at the factory and on site. However, the evidence available at present is not sufficient to measure the effect of this specific factor.

The production costs of selected building materials and components

17. The enquiry on house-building costs mentioned above confirmed that building materials represent up to and sometimes even more than 60 per cent of the total cost of construction. Attention was therefore devoted to the possibility of reducing this item of cost, and in particular to the benefits to be derived from mass production.

18. A special study was undertaken on the effect of repetition on the production cost of building materials and components, and more specifically on how production costs of selected components currently used in house construction may be and actually are reduced through a systematic limitation of the number of models produced or an increase in the length of production runs. The study was the first of its kind to be carried out on an international level, and, as far as building materials and products are concerned, has had very little precedent in national experience.

19. The problem of repetition, which is a very general one, is not restricted to the production of materials and components, but is relevant also to the design and even more so to the building operations on site; further enquiries shall be devoted to these important aspects of the industrialization of building. However, the provisional conclusions of the enquiry just concluded on the effect of repetition on the production costs of building materials and components, are briefly recalled below.

20. For factories producing several models in one production line, inventory costs are the main factor determining the optimum size of production runs of different models, taking into account the structure of demand and its influence on the variety of models and on the size of production runs of the different models.

21. Substantial cost reductions can be achieved by increasing the capacity of a factory and thus obtaining some of the benefits of mass production, even if the technique of production remains basically unchanged. The scope for cost reductions through the systematic limitation of the variety of models and the corresponding increase in the size of production runs depends on the nature of the product, on the organization and technology of the production process and on the scale of production in existing plants. The analysis show that in some cases the scope for cost reduction through limitation of the number of models is comparatively small, whereas in other cases, where limitation of the number of models will bring about a more efficient use of the capacity of the plant, an appreciable cost reduction will be possible. In some cases, limits to further cost reductions are set by the very structure of production costs; for instance, where materials costs represent more than half or even up to two-thirds of the total production cost.

22. A considerable increase in the scale of production often will entail completely new designs of products, which will be more suited to the specific requirements of mass production and will often allow great savings in materials. Such radical changes in design and in the processes of production have not been covered by the enquiry. But the effect of such changes on the reduction of costs is illustrated by the case of flush doors which are nowadays of better

and more regular quality and definitely cheaper than the traditional artisanal doors which they have replaced. The enquiry has brought to light the interconnexion between design and production, as well as the limitations of improvements which can be obtained within a given set of condition.

23. The structure of demand, together with its implications as far as the number, type and variety of models are concerned, has been assumed as one of the data to which the composition of output had to be adjusted. It was also recognized that both the production process and the production plant had been conceived and organized on the basis of a given pattern of demand. Changes in this pattern, which to a great and increasing extent, are within the realm of government policies in the field of standardization, would inevitably effect the corresponding production processes; in some cases they do and will no doubt continue to determine the setting up of entirely new plants with production techniques departing radically from those at present in use.

Initial cost and total cost: the problem of the lifetime of a building and of the expenditure on maintenance and repairs

24. So far only the initial cost of a building has been taken into account. But whatever the expected economic or social life of a building may be, some periodic expenditure will be required to maintain it in conditions suitable for the use for which it has been designed. Unfortunately, in the great majority of European countries, the sources of capital for new construction and the organs responsible for spending them are so far considered separately from the sums devoted to the maintenance and repairs of the existing stock.

25. The need was felt therefore to integrate into a single notion of "total" cost both the initial building cost and the sum of all the future expenditure required to maintain it or replace its parts over its expected lifetime. Attention was also devoted to the present level of expenditure and maintenance, to its significance in the overall house-building activities and to the main factors, both of a technical and economic nature, likely to affect it in the near future. The results of the enquiry carried out under the aegis of the Housing Committee and recently completed are briefly recalled below.

26. The present annual expenditure on current maintenance and major repairs in the countries participating in the enquiry covered a wide range; expressed in terms of the initial or replacement value of the building, this expenditure varies from a minimum of 0.5 per cent to a maximum of 2.0 per cent. However both extremes are to be considered exceptional, the lower considered insufficient and limited by the funds available for maintenance, the higher because of a considerable backlog of major repairs arising from the war and its aftermath or from prolonged housing shortages. In the majority of European countries, an annual expenditure of 1.0 - 1.5 per cent of the initial cost adjusted to current prices is, by present standards, considered adequate to maintain the dwelling in good conditions and to replace periodically those parts or components whose duration, either for technical or social considerations, is shorter than the expected life of the dwelling as a whole.

27. Irrespective of the absolute level of expenditure, between one-quarter and one-third of the total annual expenditure on maintenance is normally devoted to current maintenance. At the design stage, relatively simple and inexpensive arrangements can be made to facilitate the access to those internal parts (such as, for instance, pipes, valves, motors, etc.) exposed to frequent repairs or replacement or to facilitate the current maintenance of certain external finishes and fittings (roofing, flashings, external renderings, glazing, etc.). From

the point of view of the organization of maintenance operations, attention can be devoted to organizing "preventive" maintenance of those parts (such as, for instance, fuel burners, electric bulbs, etc.) subject to heavy wear and periodic replacement, to introducing the use of specialized light mechanical equipment and tools, or to improving the efficiency of the services responsible for carrying out emergency repairs.

28. The evidence submitted on the relationship between the age of the building and the actual level of maintenance expenditure is limited and for the time being not altogether convincing. In some countries, a slow but gradual increase of maintenance costs with age has been reported; in others, the level of maintenance costs is currently assumed to remain approximately constant over the expected lifetime of the building.

29. In spite of considerable differences of detail, it would appear possible to classify the main elements and parts of a building into a small number of categories or ranges of durability, which would be sufficiently accurate for the purpose of economic calculations. One of the main advantages of a simplified approach to the problem of durability of building elements would be to establish means of assessing and following trends in technological change in the building industry and in housing standards, especially with regard to the effect of introduction of short-life materials or more elaborate services and equipment.

30. From the evidence submitted by the few countries reporting such data, the present rate of demolition is well below what could be reasonably expected from current estimates of the average lifetime of the dwelling stock; in no case is this rate higher than 0.3 per cent per year. Although the reasons for this situation are well known, the consequences of the backlog in demolition on the accelerated ageing of the stock and on the level of future replacement needs cannot be fully measured from present statistical evidence, although it is already possible to foresee that, in order to face this situation, the share of house building activity devoted to the replacement of obsolete dwellings will have to be increased in most countries in the near future.

31. In spite of the difficulties pointed out above, it appears feasible and indeed desirable to plan future maintenance costs although future changes in technology may invalidate the initial estimate. The examples provided in the report illustrate some of these methods and stress the real benefit which could be derived from a better knowledge of the future level of maintenance costs, from the point of view both of the individual investor and of the general economy.

32. A further step in the direction of a more comprehensive approach to the economic study of housing costs is the integration of the separate notions of initial cost, future maintenance and running costs and lifetime of the building and its individual parts into a single concept of "total" or "final" cost. The enquiry shows that data on the durability of building elements and on the present level of maintenance costs are sufficiently accurate to provide a basis for such calculations, and that different methods can be used which lead substantially to the same results. The choice of the most suitable method depends of course on the purpose of the exercise and on the accuracy of the data available. But whatever the method actually used, the results of such calculations should be an important factor in guiding policy-making bodies in the choice of the type of investment most favourable within the context of the economy as a whole.

Some special problems of under-developed countries

33. The studies carried out under the aegis of the Housing Committee reflect quite naturally the preoccupations of the European countries which, together

with the United States of America, are its constitutional members. Political, economic, technical and social conditions vary a great deal within Europe as so do many of the problems which governments have to face in elaborating and implementing their policies in the field of house-building. Still greater differences arise, however, if one compares under-developed countries to the majority of European countries.

34. The first and most striking difference concerns the present level of income: under-developed countries have a national per capita income ten to twenty times smaller than industrialized countries in Europe and America. The part of that income which can reasonably be devoted to gross domestic fixed capital formation is generally lower in under-developed countries than in industrialized countries, perhaps in the order of one-half. It is also reasonable to expect that developing countries shall assign higher priority within capital formation to productive investments required to increase their overall output.

35. Construction taken in its widest sense, i.e. including civil engineering and public works, may represent a considerable part of investment; but funds for investment in residentail construction (housing and related facilities) shall have to compete with other "non-productive" investments. Many a technical solution which has proved satisfactory in an industrial country may be inapplicable in an under-developed country if the sheer volume of house construction is below a minimum threshold.

36. Needs, on the other hand, if measured by objective standards and not in terms of effective demand will continue to expand at an increasing rate as a consequence of the same factors mentioned in paragraph 4, some of which, however, might be even more accentuated in the case of under-developed countries. The gap between housing requirements and the capacity of the national economy to fulfill them is such that bold policy decisions will have to be taken if a constructive, rather than a negative, approach has to set in.

37. Some of the options to be taken might result in assigning priority to environmental sanitation, servicing and in general the basic infra-structure of development, while limiting to a strict minimum the expenditure on housing of adequate standards. In other cases it may be decided to encourage large programmes of aided self-help construction, either in rural or in urban areas, or in both. The problems of the adequate development of the building industry (or, in some cases, of its creation from nil), and of the corresponding expansion of the physical means required to carry out long-term building programmes, will be radically different in either case.

38. Some of the conditions prevailing in the under-developed countries may represent serious obstacles to the application of modern industrial techniques. Among these one could mention the prevalence of rural population, the low average density of population, the great distances separating large and small urban centres, the lack of adequate transport networks and transport facilities or the insufficient knowledge of the potential development value of local resources.

39. Another fundamental difficulty of many under-developed countries derives from the small present capacity of the local market. In many cases, only an inter-regional approach could warrant the setting up of some industries such as steel, cement, aluminium, etc., which could contribute to the local production of building materials.

40. For the time being in several under-developed countries, many building materials are imported from abroad and consume a sizeable proportion of very scarce foreign exchange. Small industries capable of producing some of the materials and components currently used in building (cement blocks, hollow bricks, floor wall and roof tiles, simple sanitary equipment, parts of the electrical installation, joinery, hardware, etc.) could usefully be set up to cater for the local market.

41. A considerable effort at standardization is vital in this respect, since for many years to come many of the under-developed countries shall have to continue to depend of foreign imports. The problem of inter-changeability of components and of their future replacement, which has been dealt with in one of the studies referred to above, may become a very serious one, as a consequence of recently acquired independence or of severage from a dominant metropolitan market.

42. The concentration of the quantitative housing shortage round the main urban areas may, on the contrary, represent an inducement to setting up plants producing relatively highly industrialized components, which could be delivered and assembled within a small radius. Technical "know-how" is nowadays available in many European countries and most of the basic technological and organizational problems have already been solved. However, some of these processes require rather heavy investment and can only be justified by a long-term and continuous programme of construction.

43. Some of the more advanced building methods, using for instance large-size prefabricated concrete components, may result in savings of total manpower, and especially a reduction of the requirements of traditional skills. The transfer of the operation from the building site to the factory, however, will create the need for new skills and for better organization and control of the whole building process. Vocational training programmes which should take these perspectives into account, could be formulated only after the adoption of coherent long-term policies.

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